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DETECTION AND EVALUATION SURVEY OF THE BALSAM WOOLLY ADELGID INFESTATIONS ON MOUNT ROGERS--VIRGINIA, 1979

by

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COVER PHOTO

Panoramic view of Mt. Rogers showing Fraser fir in background.

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CREDITS

Members from the following agencies cooperated in the 1979 BWA surveys on Mt. Rogers:

United States Forest Service

- Jefferson National Forest, Mt. Rogers National Recreation Area Ranger District

- Southeastern Area State and Private Forestry, Forest Insect and Disease Management, Asheville, N.C. and Doraville, Ga.

University of Tennessee, Department of Forestry

Virginia Division of Forestry

Virginia State Park Service

North Carolina Agricultural Extension Service

ABSTRACT

The balsam woolly adelgid (Adelges piceae Ratz.) was introduced into North America around 1900 and has subsequently spread throughout the range of its host (Abies sp.). It has caused severe damage to Fraser fir (Abies fraseri [Pursh] Poir.) in all areas of the Southern Appalachians, with one exception: On Mt. Rogers, in southwestern Virginia, previous annual aerial surveys and ground checks had never detected damage.

In June of 1979, a trapping survey was done to determine whether BWA was in fact present on Mt. Rogers. An infestation was discovered, and examination of cross-sections cut from infested trees indicated that the insect had been present for up to 17 years without causing significant damage. Sample trees were selected and marked with permanent tags in order to monitor the infestation. A second and more intensive trapping survey, completed in September, found a second infestation.

INTRODUCTION

A. History and Distribution of BWA

Adelges piceae belongs to the insect order Homoptera (Hemiptera) family Phylloxeridae (Chermidae, Psyllidae, or jumping plant lice), superfamily Aphidoidea and subfamily Adelginae. The adelgids infest only conifers. Of the 11 species known to attack the true firs (Abies), all are holarctic in origin and appear to have evolved into an ecological balance with their native hosts, becoming problematic only when they are introduced outside their natural ranges.

Adelges piceae originated in Europe, probably as a derivative of the closely related A. nusslini (Borner), where it was a relatively innocuous pest on European silver fir (Abies alba [L.] Mill). Its history on the North American continent is similar to that of several other disastrous plant pests: Introduced accidentally on nursery stock, the insect thrived and spread so rapidly that it was already well established on balsam fir (Abies balsamea [L.] Mill) in Maine and Maritime Canada before official identification was made in 1908. Damage to this commercially important fir has been extensive and occasionally severe all over the Northeast.

A separate introduction from Europe put the BWA into the western United States, where it first appeared around 1930 on noble fir (Abies procera Rehd.) and grand fir (Abies grandis [Doug.] Lindl.) near San Francisco. Damage is now widespread over the Pacific Northwest on Pacific silver fir (Abies amabilis [Doug.] Forb.) and subalpine fir (Abies lasiocarpa [Hook.] Nutt.). The last fir region to become infested was the Southern Appalachian Mountains (figure 1). In 1957, the BWA was identified on Fraser fir on Mt. Mitchell, North Carolina, and soon spread south to Mt. Sterling and into the Great Smoky Mountains National Park. Until 1979, Mt. Rogers, in southwest Virginia, was thought to be the only major area of host type to remain uninfested: Annual aerial surveys and ground checks by the United States Forest Service had never found any insects or damage.

TECHNICAL INFORMATION

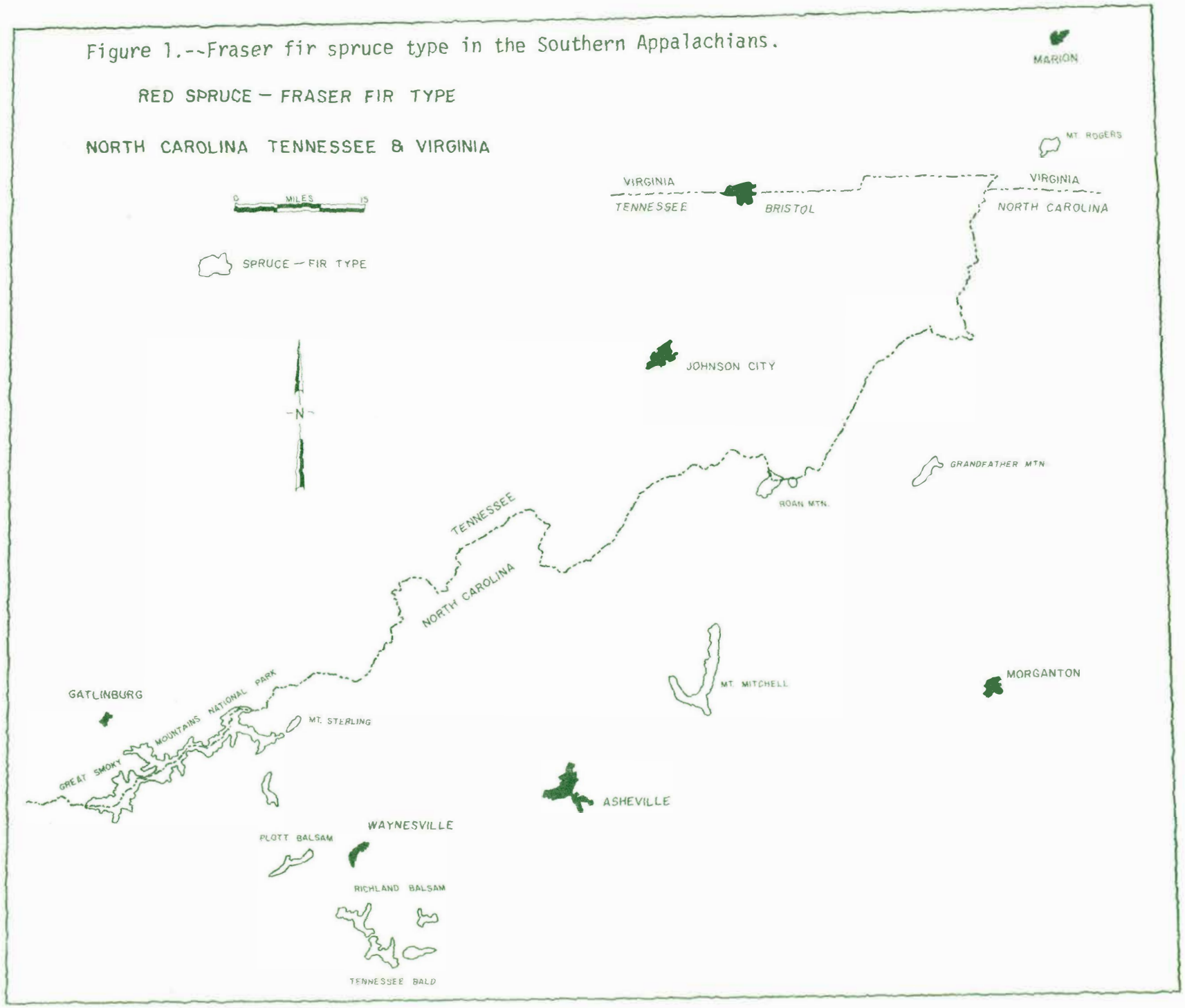
A. Life Cycle

BWA reproduces parthenogenetically, with each female producing an average of 100 eggs. The functional life cycle consists of an egg stage, three progressively larger nymphal instars, and the adult (figure 2). The amber-colored eggs (figure 3) are attached to the bark of the host. It is primarily during the first nymphal stage that dispersal occurs, as the "crawlers" (figure 4) move about on their own legs or are dislodged and are carried by wind currents. After inserting its stylet (a slender, thread-like mouth part used for feeding) into the host bark, the nymph remains stationary throughout its following nymphal molts and adult life. The insect's body becomes covered with long curling waxy threads, the characteristic "wool." Since BWA tends to congregate, the wool forms a dense protective covering and makes infestations more readily observable (figure 5). BWA overwinters as a dormant nymph, and during North Carolina summers, there may be three to four generations.

B. Damage

The BWA's stylet penetrates through the host's epidermis or pheloem into the cortex or phelloderm, where it feeds in the parenchyma. Insertion of the stylet is accompanied by ejection of saliva. A substance contained in the saliva (or produced in the cortical tissue by action of the saliva) diffuses from the point of insertion and causes parenchyma cells contiguous to the stylet to increase in number and size, due to a change in the balance of growth hormones and inhibitors in the host tissue (Balch, et al., 1964).

Figure 1.--Fraser fir spruce type in the Southern Appalachians.



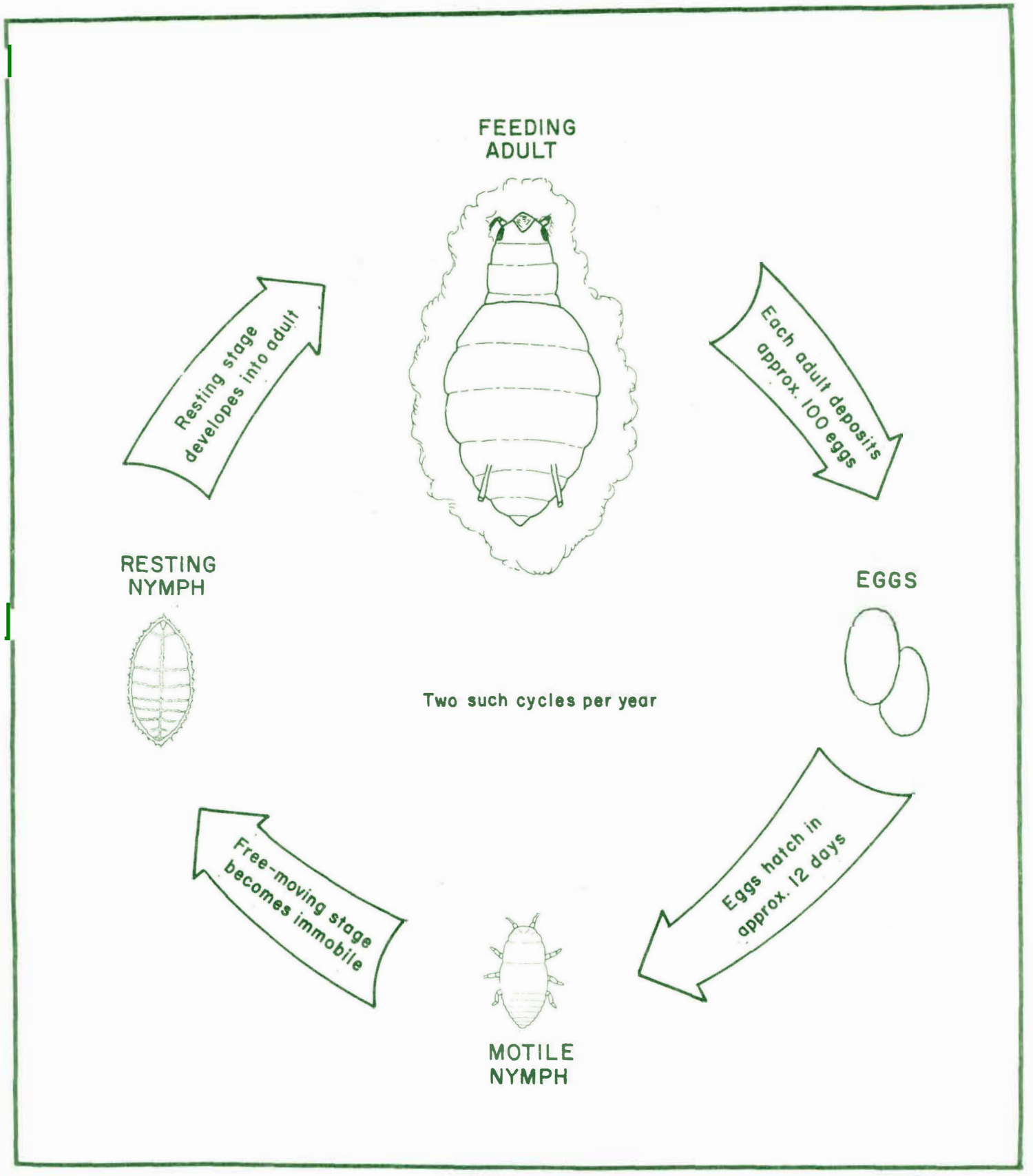


Fig. 2 Life cycle of the balsam woolly adelgid.

Figure 3.--Highly magnified egg of balsam woolly adelgid

Figure 4.--Highly magnified crawler of balsam woolly adelgid

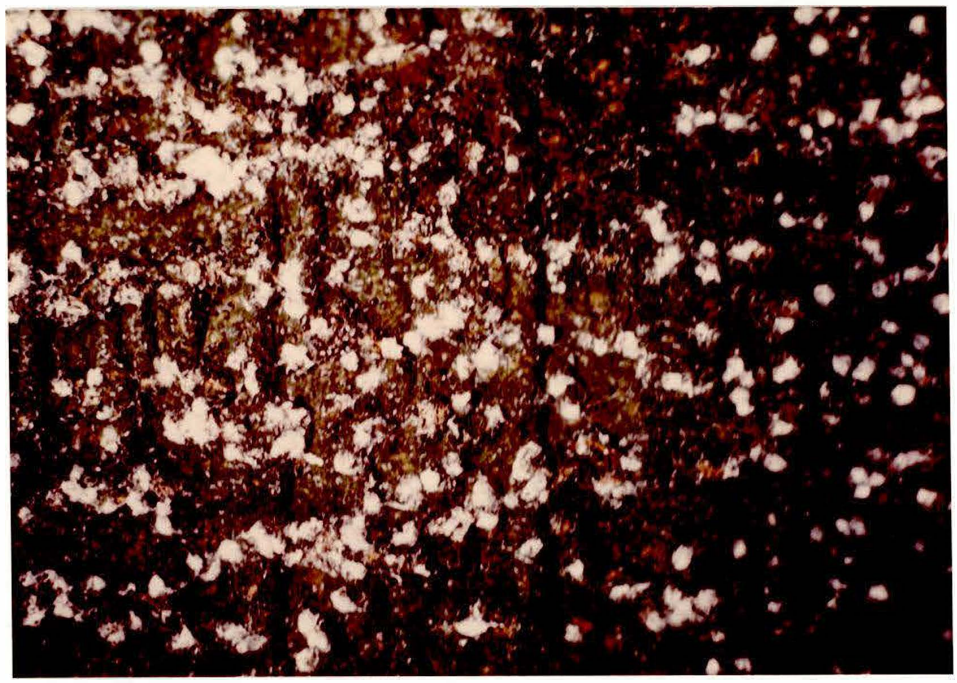


Figure 5.--Woolly masses covering bodies of balsam woolly adelgid on Fraser fir bark

This is accompanied by enlargement of the nuclei and thickening of cell walls; giant cells, six or seven times larger than normal are produced. This additional volume disrupts phloem channels, resulting in a girdling effect. By the following season, neighboring cells proliferate and form a secondary phelloderm surrounding the pockets of abnormal tissue. This represents the initial stage in the wound healing process, and European firs are able to complete this process rapidly enough to isolate affected tissues.

The salivary secretion also affects the xylem: Cell division is stimulated in the cambium, resulting in production of tracheids with thickened, irregularly shaped cells and dark, hard, brittle cellulose. This abnormal wood is known as "redwood" (figure 6). Presence of redwood can be useful in dating infestations, though its absence does not necessarily indicate that attack has not occurred. Even a heavy infestation will not always produce redwood and it is not uniform around a growth ring or along the stem vertically.

Death of the host is caused by a combination of factors:

1. Production of abnormal cells and resultant interference with translocation of fluids through the xylem

2. Killing of the outer tissues of the bark by the toxic effect of the saliva in heavy infestations

3. Production of secondary phelloderm in sufficient quantities to interfere with respiration of underlying tissues (Balch, 1952).

While the microscopic tissue changes caused by BWA attack are apparently similar in all hosts, the nature of the infestation and its effects may vary among host species. Infestations are usually classed as stem attack or crown attack, depending on where the infestation is concentrated. Crown infestation produces a swelling at the nodes (figure 7), then a deformation of shoots and internodes, followed by down-curling of branches, tip inhibition and dieback. Appreciable mortality does not occur until after 10 to 20 years, and recovery is possible (Bryant, 1974). Stem infestations usually cause death quite rapidly, often within a few years of attack, because of the direct translocation impairment. Foliage color changes from the normal healthy green to a faded yellow-green, then bright, rusty red and finally dead-brown.

Balsam fir and the intermediate bracted balsam fir (Abies balsamea var. phanerolepis Fernold) usually suffer crown attack; stem attack is more common on Fraser fir, though small suppressed trees and reproduction can develop crown gouting as aphids drop onto them from the overstory (Amman and Talerico, 1967).

Figure 6.--Disk taken from adelgid-infested tree. Note the redwood formed from hard, brittle cellulose, a consequence of adelgid salivary injections.

Figure 7.--Nodal swellings resulting from adelgid infestations in Fraser fir.

C. Study Area

Mt. Rogers (elevation 5,729 ft.), located in Grayson County, is the highest point in Virginia. It is managed by the Jefferson National Forest as a National Recreation Area. Its fir stands are disjunct, varying in age and height (figure 8). They are separated by open range land. A portion of the Grayson Highlands State Park, adjacent to the National Recreation Area, was also included in the study area.

METHODS

A. First Trapping Survey

The first trapping survey was planned for June, when the motile crawler stage would be active.

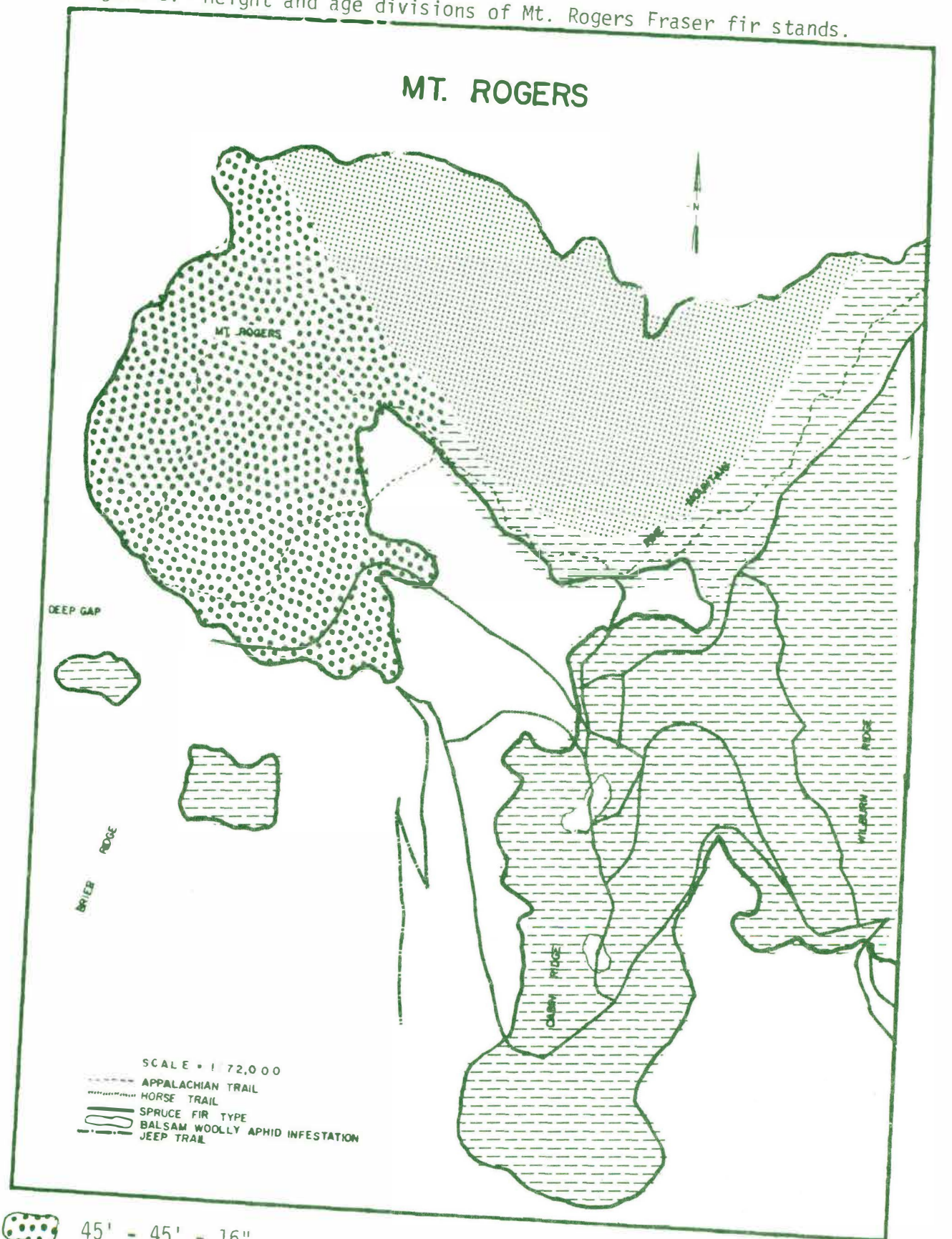
An aerial photograph of the Mt. Rogers area was used to divide the spruce-fir type into two sections (A and B) of roughly equal size (figure 9). During the first week in June, traps were placed at regular intervals along the trails (approximately 5 minutes apart by horseback), with a total of 26 trap locations in section A and 27 locations in section B.

The traps (figure 10) consisted of a slide holder supporting three microscope slides covered with Stickum Special®. Two slides were in a horizontal position and the third at an oblique angle. They were attached to the trunks of fir trees at approximately 5 feet from the ground. The height, d.b.h., and age was recorded for each tree bearing a trap.

During the third week of June, all traps were collected and the slides examined for crawlers under a microscope. Crawlers were positively identified on the trap from one location, and traps from three other locations contained objects which might have been crawlers but could not be positively identified. Upon returning to these trap locations, an infestation was verified in one area on Cabin Ridge (the location from which crawlers were definitely found on the slides). This infested area was approximately 3 acres in size. BWA infestation occurred with varying intensity, but was observed only on the lowest 15 feet of the bole. Three trees showed top dieback and two were dead; this damage may or may not have been due to BWA attack.

Cross-sectional sample disks were taken in order to examine the redwood. These were sent for analysis to two scientists familiar with BWA: Dr. Gene Amman (U. S. Forest Service - Forest Insect Research, Ogden, Utah) and Dr. John Witter (University of Michigan, Ann Arbor, Michigan).

Figure 8.--Height and age divisions of Mt. Rogers Fraser fir stands.



45' - 45' - 16"
30' - 25' - 10"
60' - 60' - 16"

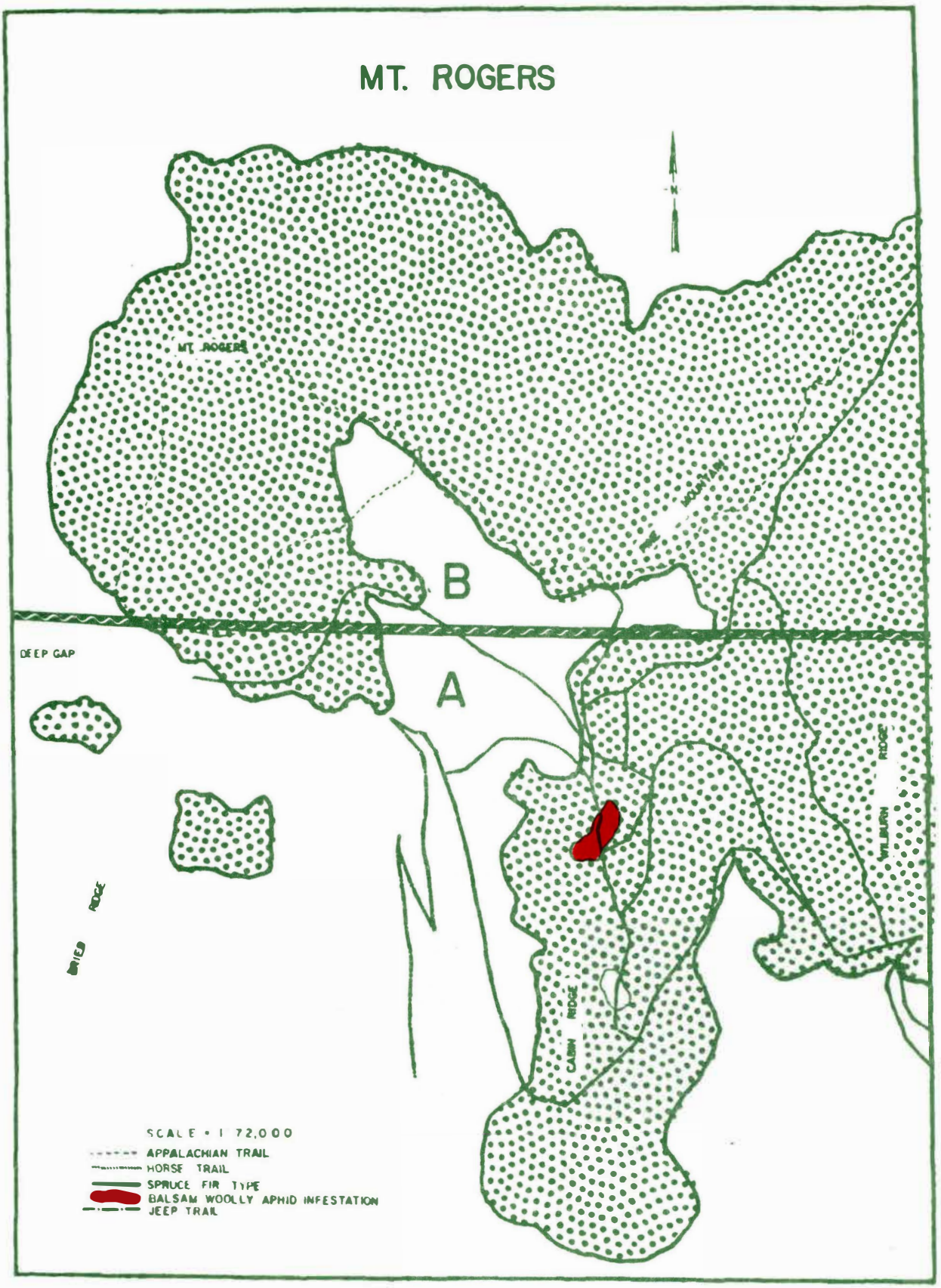


Figure 9.--Trapping divisions for June 1979 survey.

Figure 10.--Stickum-covered slides in adelgid trap

B. Permanent Monitor Trees

During mid-July, 47 trees in the infested area were selected for monitoring of the infestation in the future. Each tree was marked with a numbered, permanent metal tag, and the following data were recorded:

1. Tree number
2. Age
3. Years infested
4. d.b.h.
5. Crown class
6. Infestation (light, moderate, heavy)
7. Number of BWA per square inch
8. Percent of crown dieback

C. Second Trapping Survey

In September, a different survey technique was used to sample more intensively, particularly in the areas most suspected of being infested. Using the aerial photograph, the study area was divided into five sections (figure 11) and trap locations designated as follows:

Section A: 48 trap locations, each having three traps.
Section B: 26 trap locations, each having three traps.
Section C: 8 trap locations, each having three traps.
Sections D and E: Spot checks only.

The traps were of the same design as those used in the first survey (i.e., three microscope slides on holders banded around the tree trunk). At each trap location, three traps were set out approximately 33 feet apart in a triangular formation. Each fir in the triangle on line between the traps trees was examined for BWA; if any of the insects were found, no traps were set at that location. A second infestation was found through this procedure. It was approximately 1 acre in size and located on Cabin Ridge about ½ mile from the previously discovered infestation. The traps were put out during the second week of September.

After the traps were set, a storm and 3-inch rainfall washed some traps clean and may have interfered with the trapping success. During the fourth week of September, all traps were collected and examined and no crawlers were found.

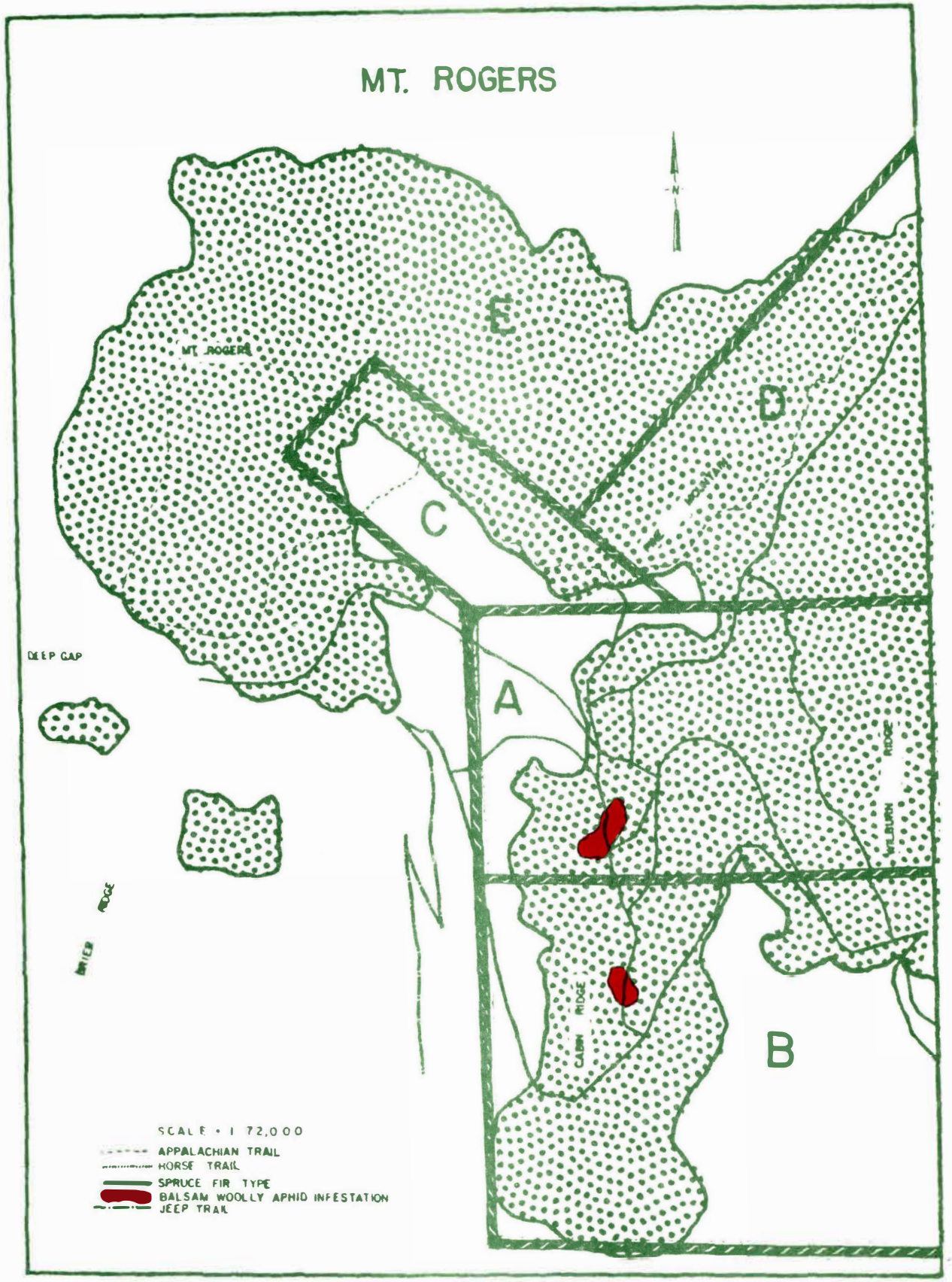


Figure 11.--Five trapping areas of September 1979 survey.

RESULTS

The 1979 trapping survey on Mt. Rogers detected two BWA infestations on Cabin Ridge. They were estimated to be 3 acres and 1 acre in size and were located approximately ½ mile apart. Within the infested areas, three trees showed top dieback and two were dead. This damage may have been due to BWA attack (figure 12). Where BWA were present, they were found only on the lower 15 feet of the trunk.

Cross-sectional sample discs were examined for redwood by Forest Insect and Disease personnel and two entomologists familiar with the BWA, Dr. Gene D. Amman[1/] and Dr. John A. Witter[2/]. The results of these examinations are presented in Table 1.

Information recorded from the 47 permanent monitor trees appear in Table 2.

DISCUSSION

Prior to 1979, the absence of apparent BWA infestations on Mt. Rogers had raised several questions:

1. Were the insects present on Mt. Rogers, i.e., were they either presently being dispersed by wind currents from other infestations in distant areas of fir type, or currently infesting firs on Mt. Rogers?

2. If the host species had been exposed to the insect, were infestations established?

3. If the trees were infested, how long had BWA been present, and why was there no apparent damage or mortality?

The 1979 survey revealed that the BWA had been dispersed to Mt. Rogers, and infestations had become established as early as 1962. The trees however, have suffered very little damage. It has been suggested that the fir on Mt. Rogers is in fact not Fraser fir, but instead, the more BWA tolerant bracted balsam fir, or a hybrid between the two. It may be that BWA population builds up then declines without harming the host (as was observed on one tree on Roan Mountain), or that the trees will die within the next few years. This phenomena cannot be explained on basis of the observations and data presently available.

[1/] Dr. Gene D. Amman, Principal Entomologist, Intermountain Forest and Range Experiment Station, U. S. Forest Service, Ogden, Utah.

[2/] Dr. John A. Witter, Associate Professor of Forest Entomologist, School of Natural Resources, University of Michigan, Ann Arbor, Michigan.

Figure 12.--Mt. Rogers Fraser fir stand damaged by balsam woolly adelgid

Table 1.--Disks or cross-sections from eight trees showing the years that redwood was produced by the tree.

Tree and Disk Number	Years of Redwood	Crown Color
1	15	Green
2	6	Gray
3	2	Green
4	3	Green
5	2	Green
6	12	Gray
7	17	Gray
8	6	Green

Table 2.--Physical characteristics and infestation status of 47 permanent Mt. Rogers monitor trees, 1979.

Tree No.	d.b.h.	Crown Class	Age	Infestation Field Check L	M	H	Lab Check Aphids/sq. in.	No. years trees infected
1	6.0	1	36	-	-	-	0	11
2	8.3	1	25	X			1	12
3	5.2	0	24	X			3	5
4[3/]	5.1	1	28	X			0	0
5	5.4	1	25	-	-	-	0	8
6	4.9	2	23	X			1	8
7	6.0	0	26	X			1	6
8	8.0	1	23	X			2	6
9	7.7	2	30	-	-	-	0	6
10	5.8	1	24	X			4	0
11	6.6	1	24	-	-	-	0	5
12[1/]	7.1	1	26			X	0	7
13	6.7	1	28	-	-	-	0	7
14	6.7	1	27	-	-	-	0	10
15	6.3	1	29	-	-	-	2	9
16	4.6	2	25	-	-	-	0	7
17	5.3	1	23	-	-	-	0	2
18	5.2	1	29		X		1	8
19	3.7	1	30	X			3	6
20	7.7	1	25	X			1	9
21	7.4	1	23	-	-	-	0	7
22	7.0	1	27	-	-	-	0	6
23	6.2	1	26	-	-	-	0	11

Table 2 continued

Tree No.	d.b.h.	Crown Class	Age	Infestation Field Check L	M	H	Lab Check Aphids/sq. in.	No. years trees infected
24	8.0	1	30	X			0	7
25	8.1	0	30	X			6	8
26	4.5	0	39		X		3	3
27[1/]	7.2	0	26			X	0	4
28	5.1	0	23		X		5	3
29[2/]	19.3	0	0	-	-	X	0	0
30[2/]	15.9	1	0	-	-		0	0
31	5.0	1	30			X	14	2
32	5.5	1	25	X			1	2
33	6.8	1	31	X			1	0
34	9.4	0	35			X	3	6
35	3.9	1	29	X			3	2
36	5.7	1	30		X		8	7
37	7.2	1	21		X		6	2
38[3/]	7.5	1	0	-	-	-	1	0
39	5.3	4	27	-	-	-	0	3
40	7.9	1	26	X	-	-	0	4
41	7.7	1	25	-	-	-	0	10
42[3/]	7.0	3	0	-	-	-	0	0
43	6.3	2	20	-	-	-	2	7
44	7.1	2	29	-	-	-	0	4
45	7.2	2	26	-	-	-	0	7
46	9.2	0	25	-	-	-	0	17
47[3/]	6.7	1		-	-	-	0	0

1/ Heavy with woolly masses, no live aphids when lab check was made.
2/ Tree was hollow, could not get core.
3/ To be rebored in 1980.

% of Crown dead: 0 - 0; 1 - 0-25; 2 - 25-50; 3 - 50-75; 4 - 75-up

RECOMMENDATIONS

Because of the possibility that the fir on Mt. Rogers represents a tolerant hybrid, no control is recommended so that these infestations may remain as study areas. To monitor the status of these infestations and their effects on host trees, another survey is recommended for June of 1980. The same type of survey should be repeated except that traps should be positioned lower on the trees, this is because current Mt. Rogers infestations are concentrated on the lower boles.

During the June 1980 survey, close examinations will be made of the infested trees detected during the 1979 surveys. In the 1980 report, a special note on the status of these infested trees will be made.

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